

NASA Aeronautics Research Mission Directorate: University Engineering Design Challenge 2013-2014

Design a High Altitude, Long Endurance Un-crewed Aerial System

Background:

Researchers have been using Global Hawk-type UAVs to gather data during the hurricane season (see reference 1, NASA HS3 mission) to improve their computer models. The models predict storm track with accuracy, but they are less accurate in predicting storm formation and intensification behaviors. Those types of predications require long-term observations and measurements. The Global Hawk-type aircraft are limited to 24 hours endurance. This challenge asks students to design a new system of next generation un-crewed aircraft platforms with much longer endurance.

Design Requirements:

The Atlantic hurricane season runs from June 1 through November 30. The new design of one or more next generation platforms should be capable of providing persistent five-month coverage over an area of the Atlantic Ocean off the West Coast of Africa where tropical depressions can form into hurricanes. This area is located at 15 deg N latitude and 25 deg W longitude near the Cape Verde Islands.

The following table lists the top-level threshold and goal design requirements. The threshold values are the minimum acceptable performance requirements, and the goal values represent desired capabilities. Most likely, trade-offs between these parameters will be required if any of the goal values are to be met, e.g., increasing endurance to 10 days or greater may require reducing payload or loiter speed. See "Trade Studies" section below for more information. The threshold loiter speed is required to enable a pattern of dropsondes to be set across the width of a typical hurricane to gather time correlated measurements. The threshold loiter altitude is set to provide adequate vertical separation distance from the tops of typical storm columns. The goal is to have at least a 10,000 ft altitude buffer over the top of the highest storm to minimize the turbulence experienced by the vehicle.

		Threshold	Goal
Loiter Speed	kts	150	250
Loiter Altitude	ft	60,000	70,000
Endurance	days	7	10+
Payload	lb	2000	3000
Payload Power	kW	9	15

Given the 2020 timeframe as the targeted initial operational capability, all technologies must be at Technology Readiness Level 6 or greater by 2015 (see reference 2 for TRL definitions).

Threshold Payload Details:

	Quantity	Weight Each (lb)	Total Weight (lb)	Dimensions Each L x W x H (ft)
Dropsonde Dispenser	4	115	460	2 x 4 x 3
Dropsondes	352	0.5	176	88 per dispenser
Interferometer	1	250	250	5 x 1 x 1
LIDAR	1	380	380	4 x 2 x 3
Radiometer	1	250	200	3 x 1 x 1
Radar	1	354	354	4 x 4 x 2
C3 Payload	1	180	180	1 x 1 x 1
Totals			2000	

Assume the goal payload includes 4 more dropsonde dispensers and another radar. Payload can be carried internally or in pods, however easy access to all payloads is required. Assume all sorties originate and terminate at NASA Dryden Flight Research Center. After launch, assume the vehicle climbs in restricted airspace above FAA controlled airspace to FL600 and is then cleared to transit across the U.S. and the Atlantic Ocean.

Trade Studies:

It is not anticipated that a 2020 timeframe vehicle will be capable of meeting all of the goal requirements simultaneously. Therefore, trade studies should be performed to quantify the trade-off between endurance and payload, loiter altitude and endurance, loiter speed and endurance, and endurance and cost. The results of these trade studies should be utilized to justify selection of the proposed concept. The objective function is to minimize overall system cost. Endurance, speed, payload and altitude can be traded to reduce overall system cost, however all threshold requirements should be met by the proposed concept. The cost trade should be executed in terms of finding the optimum number of vehicles to provide continuous coverage. Larger, more expensive vehicles will tend to have greater endurance, reducing the number required for continuous coverage; however the overall system cost may be less by utilizing larger numbers of smaller, less expensive vehicles.

Design Paper (see submission and format section of contest website for complete details on length, required ancillary elements, and appendices):

The paper is limited to 25 pages and should include a discussion of the requirements, including the identification of the design driving requirements and all derived requirements (An example of a derived requirement would be the required payload locations to provide line-of-sight communications to a satellite or ground control station during takeoff and landing operations.).

A thorough literature search should be performed, and a comparator aircraft should be identified. Top-level dimensions, weights, and key performance parameters should be presented for comparator aircraft.

Several alternative solution concepts with various propulsion options should be generated and a systematic qualitative and/or quantitative screening process should be presented to provide justification for the proposed concept. All tools and methods utilized to design and analyze the concept should be briefly described, including tool validation and verification of results utilizing sanity checks, rules of thumb, historical data, etc.

At a minimum, the following data should be provided for the proposed concept:

- Dimensioned three-view drawing
- List of key technologies and justification that they will meet the TRL=6 level in 2015.
- Internal arrangement drawing showing location of major sub-systems and structure
- Table showing weight build-up including structures weight (wing, fuselage, tails, etc.), propulsion system weight, payload, fuel, etc. Table should include empty weight, zero fuel weight (empty weight + payload weight), and takeoff gross weight.
- Table showing key performance parameters such as takeoff and landing distance, climb rate, cruise and loiter speeds and altitudes, endurance, cruise L/D, cruise SFC, and payload.
- Concept of operations for a typical mission including communications, data collection and storage or transmission, flight profile and launch and recovery operations.
- Cost analysis for development, production, and operation of the proposed vehicle (s).

References:

1. NASA Hurricane and Severe Storm Sentinel (HS3) Mission
<http://espo.nasa.gov/missions/hs3/>
2. Mankins, John C., "Technology Readiness Levels", April, 1995.
<http://www.hq.nasa.gov/office/codeq/trl/trl.pdf>